

Mauricio Suárez

## In defence of scientific realism

**From Physics to Metaphysics**  
Michael Redhead 1995 Cambridge  
University Press 92pp £19.95hb

THE philosophy of physics is now an important branch of academic philosophy. Philosophers of physics, who usually have a background in both disciplines, address the kind of questions that any physicist interested in understanding the conceptual foundations of the subject would deem important. These might include: What is four-dimensional Minkowski space-time, and how did the advent of relativity affect Newtonian views of absolute space and time? Are the standard distributions in statistical physics a measure of objective chance or a lack of information about physical processes? Is there a measurement problem in quantum theory?

Michael Redhead is one of the most prominent philosophers of physics in the UK. He was elected to be chair of the History and Philosophy of Science Department at Cambridge University in 1987, and in 1993 he delivered the prestigious Turner Lectures at Trinity College. The four lectures have now been published in a concise and readable book (with four corresponding chapters) entitled *From Physics to Metaphysics*.

Throughout the book, Redhead sets out to defend a kind of objectivity in science – a “view from nowhere” – against attempts to introduce subjective perception and consciousness in resolving some scientific puzzles. He also argues for a robust realism about scientific theories. This is the view that the fundamental theories of physics are, at least to an approximation, literally true descriptions of the physical world – the entities and processes that these theories invoke are really “out there” and not just useful fictions that help us to classify our knowledge of the phenomena.

The first chapter is a defence of scientific realism against social constructivism. Redhead claims that social constructivism is an absurd position, partly because it contradicts realism. This is a strong claim, especially given that the epistemological beliefs of social constructivists are abstract and difficult to pin down. Sociologists study our knowledge of the external world as the outcome of social interactions. Social constructivists believe that the

entities and processes described by physics are social objects, which are constructed via such interactions. According to them, the entities of physics are, in a sense, fictions that are shorthand for complicated social objects. Although social constructivism is compatible with a strong “social realism”, it opposes traditional scientific realism because it assumes that physics is driven by more than just the search for truth. It also sees scientific claims as complex statements about something other than the natural world.



Despite this, it does not follow that social constructivism is absurd or that it contradicts all forms of realism. Redhead does not make clear, for instance, why social

constructivism cannot be made compatible with Van Fraassen's agnosticism about the non-observable part of our theories, which, although not realism, is not an absurd position. Nor does he explain why social constructivism cannot use a criterion of social manipulativity that would point to a realism similar to Ian Hacking's “entity” realism. This form of realism holds that the entities described in experimental physics, such as “electron” and “neutron”, refer to real entities, but it does not accept that the most abstract laws of physics can be treated in the same way.

Indeed, Andrew Pickering, one of the leading social constructivists, has embraced a very similar form of realism. Redhead's bold claim seems to ignore much of the plurality and complexity of views available – both among realists and social constructivists – and the result is close to a caricature of social constructivism that its supporters will find easy to reject.

In the second chapter, some attempts to bring subjectivity into physics are dismissed. The discussion is lively and engaging, and a number of popular

misconceptions in the interpretation of special relativity, classical statistical physics and quantum mechanics are dispelled.

Next, in a chapter entitled “Experimental metaphysics”, the issue of contextuality in quantum mechanics is raised. Kochen and Specker's result implies that values cannot be assigned to all observables of a quantum

system at the same time while still obeying the functional relationships between the observables, unless some kind of contextuality is accepted. However, in a Bell-type situation, a composite system, composed of two subsystems, is said to be in an entangled state, and a choice must be made: one either rejects a condition called ontological locality (OLOC) or a condition called environmental locality (ELOC). OLOC says that the values of the observables of a subsystem are independent of the values of the observables of the composite. ELOC states that the specification of the values of observables of one subsystem do not depend on the physical arrangements of the apparatus that measure the other subsystem.

Redhead believes that there are substantive reasons to reject OLOC rather than ELOC, and hence that there are empirical reasons to reject the thesis of metaphysical reductionism – that physical quantities of a composite system are functions of the independent physical quantities of the subsystems from which it is composed. In the fourth chapter he argues that, without such reductionism, the prospects of a “theory of everything” are weak.

However, Redhead's rejection of metaphysical reductionism may be too hasty. OLOC is rejected because, according to Redhead, the alternative – the rejection of ELOC – implies causal action at a distance, and thus it is ruled out by special relativity. However, it is not shown clearly why the rejection of ELOC implies causal action at a distance while the rejection of OLOC does not, nor whether relativity actually forbids all such actions.

These questions are the focus of much contemporary debate. They are issues of interpretation, and hence cannot be settled

by evidence, which partly explains the present lack of consensus. However, if they cannot be settled by evidence then they can hardly be used to provide experimental evidence against metaphysical reductionism.

To sum up, the publication of *From*

*Physics to Metaphysics* offers physicists an opportunity to gain an overview of some of the issues in the philosophy of physics. It also gives philosophers a chance to take stock and assess the progress made in the field in the last few years. Redhead has certainly written a thought-provoking book

and, although some of his claims are open to disagreement, this is a sure sign that honest and serious intellectual work has been done.

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Manfred Rühle

## Interfaces are everywhere

**Interfaces in Crystalline Materials**  
A P Sutton and R W Balluffi 1995 Oxford  
University Press 819pp £95.00hb

"THIS is to announce the happy arrival of a healthy, bouncing last movement. Father and infant doing well as can be expected, the latter not yet out of danger. Silent sympathy is requested. No flowers by request." Gustav Mahler wrote this note to his brother Otto on finishing his second symphony more than six years after he started it. Sutton and Balluffi, having completed this book after about the same length of time, must have had similar feelings. The resulting monograph is heavy, and in more ways than one. It is 819 pages long, weighs 1.7 kg, and took me four transatlantic flights and many evenings to study it in full. Fortunately, it is clearly written and reports all the relevant facts in a sober, if sometimes dry, style. It is certainly an impressive achievement.

Interfaces are indeed everywhere. It is well known that many materials are not single crystalline, but polycrystalline in nature. The properties of such materials are often controlled by the behaviour and properties of internal interfaces. This is especially true if the volume density of crystalline interfaces becomes large, as happens in nanomaterials. Understanding the behaviour of interfaces is therefore vital for many applications in materials science. For example, miniaturized components made from nanomaterials, which have small dimensions and small crystallites, are becoming more widespread.

There has been extensive research into grain boundaries over the last two decades. For example, millions of dollars have been spent, mainly in the US, in determining the structure of a particular grain boundary in gold, known as  $\Sigma 5$ . The results so far have been disappointing and confusing, largely because computer models have not been related to the world of real materials.

The literature covering the subject is therefore extensive, including conference proceedings and well established, but now outdated, text-books. However, most text-books are written by a number of authors, often leading to unacceptable heterogeneities in the text. This volume, which

provides a coherent and critical review of all the results in interface science, is therefore long overdue. Sutton and Balluffi have succeeded in pulling all the established results, including those for the  $\Sigma 5$  boundary in gold, into an impressive monograph.

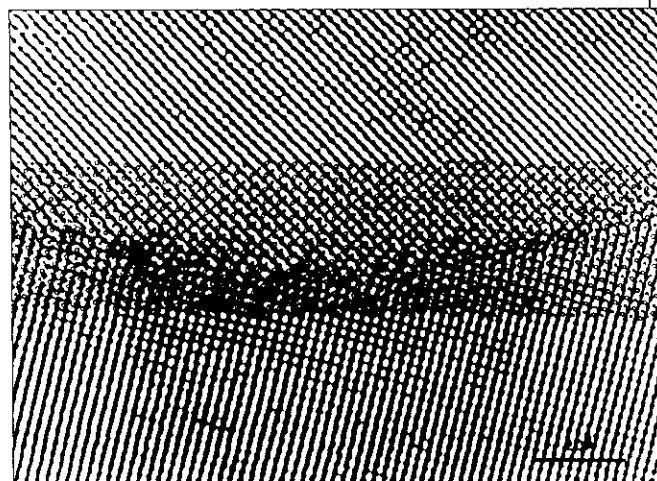
The book concentrates on grain boundaries in metals, although some subchapters are devoted to ceramics and metal/ceramic interfaces. (Outer interfaces, i.e. surfaces, are not covered.) There are four main parts. Part I discusses all aspects of interfacial structure. It covers the geometrical description of interfaces, including many details of bicrystallography. This subject clearly fascinates the authors since they describe it at some length, but these aspects seem to be overemphasized.

They point out that these crystallographic and geometrical descriptions do not take account of any physics, such as energetics. An alternative way of describing interface structures, which experimentalists often use, follows a dislocation model. The authors describe this idea in rather an abstract way, and more illustrations would have been helpful.

Part I also describes how interatomic potentials in a material can be determined. These are needed for detailed simulations of interface structure, which assume that interatomic potentials derived for the perfect material are also valid for the distorted region next to an interface. This section is well written and very helpful. It covers all of the relevant literature and contains many details, sometimes too many, although the 340 pages may be useful for scientists working in the field. For non-specialists, however, reading certain sections can be quite exhausting.

Part II covers interfacial thermodynamics and, being just 120 pages long, seems rather short. This important chapter also covers phase transformations, phase stability and the different phases that can exist at interfaces. It includes a description

of John Cahn's rather complex theoretical model, which was published in 1982. Overall, this subject should have justified a more enthusiastic approach and a more



All that glitters – a curved segment of a  $\Sigma 5$  boundary in gold

detailed description.

Part III covers interfacial kinetics, which play a key role in the real world of materials at finite temperatures. There are several interesting and stimulating subchapters on the diffusion of point defects along interfaces, an important consideration for all problems in material science (including sintering), and on conservative and non-conservative motion along interfaces.

Finally, Part IV describes the influence of crystalline interfaces on material properties. At just over 100 pages long, this chapter is again too short. Perhaps this reflects the tendency of scientists working in this area not to worry too much about materials in the real world.

The book is sure to make an impact in the materials science and solid-state physics communities. It is written in an objective style and includes all the established facts about crystalline interfaces, although the scientific approach can sometimes seem rather dry. Sutton and Balluffi focus on the essential issues, including all the aspects that are important for the overall theme of the book, and it is refreshing to see that they have not included any speculative results. The relevant literature is reviewed extremely